Distribution and Condition of *Sonneratia caseolaris* Mangroves in the Siak River Tidal Area, Pekanbaru City

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Abstract. This research was carried out in the tidal area of the Siak River, Pekanbaru, Riau Province. The purpose of this research is to determine the distribution and condition of *Sonneratia caseolaris* in the tidal areas of the Siak River in Pekanbaru as a basis for assessing future sea level rise. The method used in this research is a survey method and purposive sampling technique was used to determine the sampling points. The distribution of *S. caseolaris* was mapped by determining the current most upstream distribution point. *S. caseolaris* is presented in terms of tree diameter and condition. The distribution and condition of *S. caseolaris* were analyzed descriptively. The results show that the distribution of *S. caseolaris* in the upstream direction currently reaches the point 0°32'48.39" N and 101°27'25.97" E. The density of *S. caseolaris* ranged from 1.67 – 2.67 ind/100m^2 for the sapling group and ranged from 3.67 – 18.67 ind/100m^2 for the tree group. *S. caseolaris* is found along river flows towards the estuary with tree diameters ranging from 1.91 – 3.82 cm for sampling and 4.14.- 48.09 for tree. The average diameter of the tree becomes larger towards the river mouth.

1 Introduction

Global warming has caused numerous environmental problems that negatively impact life, such as rising sea levels, increasing intensity of extreme weather phenomena, and changes in the amount and patterns of rainfall. Other impacts of global warming are the impact on agricultural output, the disappearance of glaciers, and the extinction of various types of animals. When the atmosphere heats up due to global warming, the surface layer of the ocean will also heat up so that its volume will increase and raise sea levels. Rising sea levels due to global warming also have various impacts on ecosystems and life in coastal areas.

Other impacts on the influence of tides and the potential for permanent sea level rise

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observed by experts include changes in the state of coastal ecosystems, increased erosion, accelerated damage to buildings, settlements, industry, rural agriculture, including disruption of population activities such as other activities. In general, the situation and level of damage that occurs will vary depending on the use and conditions of use of the coastal area [1]. Coastal ecosystems that are influenced by rising sea levels include mangrove ecosystems. Essentially as a dynamic coastal ecosystem, mangroves have the ability to adapt to respond to environmental changes. When sea levels rise, mangroves will move towards land and form new zones.

One factor that influences the distribution of mangroves is salinity. This causes mangrove vegetation to not only be found along the coastline and river mouths, but can also be found several kilometers from the river mouth towards the river upstream. This is influenced by the salinity concentration in these waters [2]. The Sonneratia caseolaris mangrove forests along the Siak River in Riau Province can now be found in the Pekanbaru area, more than 100 km from its estuary. Its distribution is estimated to extend farther from the river estuary as sea levels rise, but this has not been documented or has no scientific data. The aim of this study is to assess the current distribution and condition of the mangrove species *Sonneratia caseolaris* as a baseline for measuring future distribution changes caused by rising sea levels due to global warming in the Siak River, Riau.

2. Material and Methods

2.1 Time and place

This research was conducted in July-August 2024 in the tidal area of the Siak River in the Pekanbaru ~~are~~a, Riau Province (Figure 1).

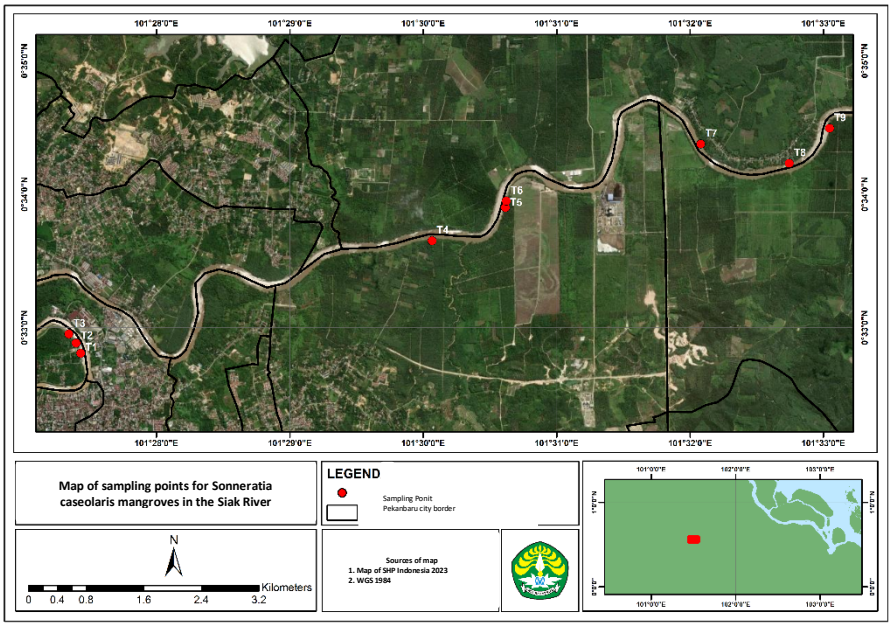

Fig.1. Map of research locations

2.2 Material and Tools

The materials and tools used for data collection on the distribution and diameter of Sonneratia caseolaris trees in the field include raffia string and measuring tape, while the instruments for measuring water quality are a thermometer, refractometer, and pH meter.

2.3 Research methods

The method used in this research is a survey method. To collect data, direct observations and measurements were made in the field.

2.4 Research Stations

The sampling stations were determined using purposive sampling techniques, which involve selecting stations based on specific considerations [3]. In this study, these considerations include environmental conditions and human activities along the banks of the Siak RiverIn this study, the research location along the tidal area of the Siak River in Pekanbaru, where S. caseolaris was found, is divided into three stations: Station 1 around Vihara Jalan Pesisir Rumbai (1: 0°32'48" N and 101°27'25" E; 2: 0°32'52" N and 101°27'23" E; 3: 0°32'57" N and 101°27'20" E), Station 2 in the Tenayan area (4: 0°33'54" N and 101°30'37" E; 5: 0°33'57" N and 101°30'37" E; 6: 0°33'39" N and 101°30'4" E), and Station 3 in the Okura area (7: 0°34'22" N and 101°32'4" E; 8: 0°34'13" N and 101°32'45" E; 9: 0°34'30" N and 101°33'2" E).

2.5 Research Procedure

2.5.1 Water Quality Measurement

The water quality parameters in the mangrove ecosystem measured in this research are temperature, salinity and acidity (pH). Measurements were carried out at high tide with three repetitions.

2.5.2 Distribusi Sonneratia caseolaris

Observations of the distribution of *S. caseolaris* in the field were carried out along the Siak River in the Pekanbaru area using land and water transportation modes. This observation also pays attention to the extent to which *S. caseolaris* mangrove vegetation can grow towards the upstream of the river by determining its coordinate points.

2.5.3 Density and diameter of Sonneratia saceolaris

The data collection of the density and diameter of *S. caseolaris* trees was conducted based on transect plots with an area of 100 m² [4]. At the predetermined points, the coordinates were recorded using GPS. In each at the predetermined points, the coordinates were recorded using GPS. In each plot, the number of trees was counted,

and the diameter at breast height (1.3 m) was measured for tree groups and saplings, while the number of seedlings was only counted.

Density (Di) is the *S. caseolaris* contained in one unit area:

$$Di = ni/A$$

Note: Di = density of *S. caseolaris* (tree/100 m^2), ni = number of stands of *S. caseolaris*, A = total area of the sampling area (100 m^2)

Tree diameter at breast height (DBH) of *S. caseolaris*:

$$DBH = CBH\ (cm)/\ \pi$$

2.6 Data Analysis

Data obtained from the field were processed using Microsoft Excel to obtain the density and average diameter of each tree. The results of the analysis are discussed descriptively.

3. Result and Discussion

3.1 General Conditions of Research Locations

The Siak River is one of the large rivers in Riau Province. The upstream of the Siak River is located in Rokan Hulu Regency. The Siak River crosses the Pekanbaru City area and empties into Bengkalis Regency and was once said to be the deepest river in Indonesia, but is currently believed to have experienced shallowing due to human activities along this river. In addition to settlements, a common activity along the banks of the Siak River is palm oil plantations.

3.2 Water Quality Parameters

The results of water quality measurements in the tidal area of the Siak River in Pekanbaru at each station can be seen in Table 1.

Table 1. Average Water Quality Measurements in the tidal area of Pekanbaru City

No.	Parameter	Unit	Station		
			1	2	3
1.	Salinity	‰	0	0	0
2.	pH	-	5.5	5.5	5.5
3.	Temperature	°C	29	29	30

In Table 1 it can be seen that the average water quality parameters at each station are relatively the same. The water quality measurements in the tidal area of the Siak River in Pekanbaru show a water salinity of 0‰, water temperature of 29-

30°C, and water pH of 5.5. According to Wijayanto [5] *S. caseolaris* lives in an environment with a salinity of 0 – 15 ppt in the Calik Banyuasin River area. The temperature at the study site ranges from 29-30°C, including conditions that are still good and suitable for aquatic life [6].

3.3 Distribution of Sonneratia caseolaris

The results of observations of *S. caseolaris* in the tidal area of the Siak River in the Pekanbaru City area were found to be uneven, only at certain points, both on the left and right sides of the river. The point where *S. caseolaris* is found is furthest towards the upstream of the Siak River, namely at coordinates 0º32'48.39" N and 101º27'25.97" E. *S. caseolaris* was not found in all areas of the tidal regions of the Siak River in Pekanbaru. As we move downstream, *S. caseolaris* is increasingly found on both the left and right sides of the river (Figure 2).

Fig.2. *Sonneratia caseolaris* in the Siak River

In comparison, Mulyadi [7] stated that *S. caseolaris* is only found towards the upstream part of the central part of S. Siak, namely Buatan, so currently there has been a shift in the distribution of this type of mangrove towards the upstream direction. This is supported by what was found by Rahmadan et al. [8] that *S. caseolaris* was found in the Siak River in the Pekanbaru City area even without clear coordinates for its whereabouts. Sonneratia was found growing along the corridor of the Siak River between Buatan Village and Sigentil Hamlet, Teluk Rimba Village [9].

3.4 Condition of Sonneratia caseolaris

3.4.1 Density of S. caseolaris

The results of the density calculations of *S. caseolaris* from the tree and sapling groups at each station can be seen in Table 2.

Table 2. Density and diameter at chest height of *S. caseolaris* at each station

Stat.	Plot	Tree Density (ind./100 m^2)	Sapling Density (ind./100 m_2)
1	1	3	0
	2	4	3
	3	4	2

Stat.	Plot	Tree Density (ind./100 m^2)	Sapling Density (ind./100 m_2)
	Ave.	**3.67**	**1.67**
2	1	12	1
	2	12	1
	3	19	4
	Ave.	**14.33**	**2**
3	1	19	1
	2	18	3
	3	19	4
	Ave.	**18.67**	**2.67**

In Table 2 it can be seen that the density of tree groups is higher than that of sapling groups at each station. Apart from that, it can be seen that the density of *S. caseolaris* is getting higher the closer you are to the river mouth. The highest average density of tree groups was obtained at station 3, namely 18.67 ind/100m^2 and the lowest at station 1, namely 3.67 ind/100m^2. The highest sapling group density was at station 3, namely 2.67 ind/100m^2 and the lowest at station 1, namely 1.67 ind/100m^2.

S. caseolaris seedlings began to be found in plot 2 towards the estuary at station 1. The density of seedlings became denser towards the downstream of the Siak River flow. The average density of seedlings at station 1 is 5.3 ind/100m^2, Station 2 is 23.3 in/100m^2, and station 3 is 40 ind/100m^2. The density of S. caseolaris, both groups of trees, saplings and semains which are increasingly denser towards the river mouth and the tree diameter size which is relatively larger towards the downstream or estuary of the Siak River indicate that the distribution of S. caseolaris begins from the river mouth which continues to shift towards the upstream of the river. The density of *S. caseolaris* in the tidal area of the Siak River is high compared to that obtained by Pratiwi et al. [10] which was only 6.22 ind/100m^2. Meanwhile, Ronavia et al. [11] found the density of *S. caseolaris* in Tahura Ngurah Ray Bali ranging between 177 – 1397 individuals per hectare. According to Noor et al. [12], *S. caseolaris* usually grows on the edge of mangrove land where the water is not too salty and along small rivers that are still influenced by tides, with high muddy substrates.

3.4.2 Diameter of S. caseolaris

The results of the diameter measurements of *S. caseolaris* from the tree and sapling groups at each station can be seen in Table 3.

Table 3. Diameter at chest height of *S. caseolaris* at each station

Stat.	Plot	Tree diameter of *S. caseolaris* (cm)	Sapling diameter of S. *caseolaris* (cm)
1	1	8.92 - 9.55	0
	2	6.60 – 12.42	2.87 - 3.18
	3	8.28 – 9.24	3.18 – 3.18
	Ave.	**10,40**	**3.18**
2	1	4.46 – 39.81	3.82
	2	6.69 – 40.13	3.18

	3	4.14 – 32.17	1.91 - 3.50
Stat.	**Plot**	**Tree diameter of *S. caseolaris* (cm)**	**Sapling diameter of S. *caseolaris* (cm)**
	Ave.	**37,37**	**3.50**
3	1	5.10 – 43.95	2.55
	2	4.46 – 48.09	1.59 – 3.18
	3	4.46 – 31.85	1.59 – 3.50
	Ave.	**41,30**	**3.07**

Table 3 shows that the highest diameter of the tree group was found at station 3 which was closer to the river mouth, namely 41.30 cm. The diameter of the tree group at station 2 is 37.37 cm, station 1 is 10.40 cm. The diameter of a tree indicates its size, which generally can also reflect the tree's age. The results of this study show that the age of *S. caseolaris* at station 1, which is closest to the river's upstream, is the youngest, and it is estimated to have grown most recently due to the rising sea level. Herdiana et al. [13] stated that diameter can be influenced by the intensity of light received, age, and the number of leaves related to the photosynthesis process.

S. caseolaris with large diameters were frequently found dead in the tidal areas of Pekanbaru. This phenomenon, known as dieback, is thought to be caused by the roots of *S. caseolaris* being submerged for a long time due to flooding in mid-November 2023 to mid-January 2024. Djamaluddin [14] stated that one of the causes of mass mangrove death, known as dieback, is prolonged flooding. While short-term flooding may not kill mangrove forests. According to Hidayah et al. [15] the decline in the condition of the mangrove forest in Benoa Bay is thought to be due to the dieback phenomenon.

4. Conclusion

S. caseolaris in the tidal area of the Siak River in the Pekanbaru City area was found to be distributed unevenly, only at certain points, both on the left and right sides of the river. The point where *S. caseolaris* was found is furthest towards the upstream flow of the Siak River, namely at coordinates 0º32'48.39" N and 101º27'25.97" E. The density of *S. caseolaris*, both in tree and sapling groups, increases as the point moves toward the estuary. The average diameter of the tree becomes larger towards the river mouth.

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